This new technology offers a small highly calibrated instrument for use in aircraft and uninhabited airborne vehicles.

The NASA–USFS Environmental Initiative and NASA's Office of Earth Science Natural Hazards Program sponsored the development of an instrument package to meet the needs of the disaster community. Requirements and specifications summarized by many user workshops and conferences resulted in the microbolometer being integrated with two visible/near infrared digital cameras to provide vegetation (fuel) and fire data.

The Brazil deployment provided a unique opportunity to test and evaluate this new technology. To characterize the variability found in savanna and tropical forest fires, and to map forest clearing, this system was flown over prescribed fires and forests of central Brazil. For the first time, this system provided calibrated multispectral data of fire activity resulting in fire temperature and intensity information. The data from FireMapper will allow scientists to compare fire behavior over differing ecosystems and vegetation types. This information will provide a better understanding of the importance of fire in greenhouse gas generation and ecosystem succession. Other collaborators in this research were P. Riggan and R. Lockwood, USFS; J. Hoffman, Space Instruments, Inc.; J. A. Peréira, IBAMA, Brazil; E. Stoner, U.S. Aid for International Development; H. Miranda and A. Miranda, University of Brasilia, Brazil; T. Krug, Brazilian Space Institute, Brazil.

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VINTAGE: Viticultural Integration of NASA Technologies for Assessment of the Grapevine Environment

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The quality of wine grapes is influenced by such factors as ratio of fruit weight to vine leaf area, amount of sunlight directly intercepted by grape clusters, and water stress levels. Vineyard canopy density (leaf area index (LAI)) is thus a key variable of interest. California premium winegrowers are making increasing use of optical remote sensing as an additional tool for monitoring canopy density and managing vineyards. In particular, prior NASA research has demonstrated the use of high spatial resolution (two meters) vegetation index imagery for subdividing individual fields ("blocks") for harvest based upon end-of-season vigor, as inferred by canopy density. Block segmentation can result in more uniformly mature wine "lots" and, ultimately, in some cases, in improved wine quality. The VINTAGE project is a public-private partnership dedicated to the further development of geospatial technologies and process modeling as vineyard management tools. Project investigators continue to examine relationships among vine stress, canopy development, and resulting wine quality by combining remote sensing with an agro-ecosystem process model.

Ground-based measurements of LAI were made on 50 vineyard plots (~405 hectares) located on two different Napa Valley ranches owned and operated by the Robert Mondavi Winery. The LAI2000 Plant Canopy Analyzer (LI-COR, Inc., Lincoln, Nebraska) was calibrated with destructive harvest of 12 grapevines (i.e., measurement of fruit, leaf and stem weights, leaf area). Global positioning system (GPS) measurements were made of all 50 plots

for accurate positioning with respect to the imagery. Two-meter multispectral images were collected above the two sites with an airborne ADAR-5500 digital camera system (Positive Systems Inc., Whitefish, Montana, USA). A reasonably strong relationship was found between aerial image Normalized Difference Vegetation Index (NDVI) and the LAI estimated from the ground ($r^2 = 0.61$). This result is encouraging, as it suggests that the simple NDVI is useful for estimating canopy cover over vineyard blocks of differing planting density, age, and trellis type.

Several additional field measurements were made during the last growing season. Eight sample plots, representing a variety of trellis systems, planting density, age, and plant variety were selected for one-dimensional (1-D) model validation. LAI measurements were taken at these plots every 7-10 days beginning shortly after budbreak, based on a relationship between shoot length and shoot leaf area to shoot length. Leaf water potential and soil moisture were measured periodically at each plot. Digital soils data were acquired for all of Napa County from the U.S. Department of Agriculture Natural Resources Conservation Service/Soil Survey Geographic (NRCS/SSURGO) data base, which is the finest resolution and detail data base available. These data were projected to the State Plane coordinate system, which is the projection of choice for Mondavi and most of the winegrowing community. A 10-meter digital elevation model was downloaded from USGS and projected to State Plane coordinates. An independent vendor created and delivered a high-resolution (1.5 meter) Digital Elevation Model (DEM) for the study area. A software procedure was written to automatically download weather data from Napa Valley weather stations on a daily basis. Irrigation quantities were recorded weekly at each site. Subsurface measurements of soil depth and

moisture were taken with a ground penetrating radar. As a result of the work, project staff are now positioned to conduct 1-D validation runs of the BioGeochemical (BGC) model (see below). This effort will give the first indication of goodness of fit, and may expose areas of weakness that call for model alteration or enhanced data collection.

An ecosystem process model was adapted for use in the agricultural setting. The model, called Agricultural BioGeochemical Cycling (Ag-BGC) is customized with physiological parameters obtained from literature on grape physiology. A prototype user interface was developed for the model allowing the input of LAI estimates derived from satellite or aircraft data. Additionally, the model can now be run with different timesteps (daily to yearly). An irrigation function was incorporated to compute timing and amount of irrigation needed to maintain vines at a prescribed target leaf water potential (water stress level). Using the LAI, soil and daily weather data, the model will calculate evapotranspiration and soil moisture on a daily basis. The spatial resolution depends on the availability of LAI data and terrain information. The model was tested on a vineyard block of Mondavi Winery. LAI (estimated from aircraft imagery) was combined with soil maps and daily weather data. As a demonstration, the model was run to estimate irrigation requirements for this particular block to maintain the vines at -1.5 mega pascals (Mpa). Results are currently under evaluation.

Another demonstration of Ag-BGC was performed to show the effect of vine spacing on water use. Transpiration and leaf water potential were simulated for a hypothetical year representing the average climate observed from 1985-1997. The onset of water stress as a function of LAI (row/vine spacing) was examined, as was the amount of irrigation needed to maintain vines at a target leaf water

potential (-1.2 Mpa). The results are being evaluated.

Vestra Resources, Inc., an Ames' partner, is developing a hardware, software, and data structure for viewing the VINTAGE model results using a mobile field geographic information system (GIS)-based solution. The portable solution will allow multispectral imagery, VINTAGE model output, and other GIS data layers to be viewed and manipulated under field conditions.

The following individuals and companies collaborated with Ames researchers on this project: R. Nemani and M. White, University of Montana; Robert Mondavi Winery, Oakville, California; Vestra Resources, Inc., Redding, California; Bay Area Shared Information Consortium (BASIC), San Jose, California; Y. Rubin, University of California, Berkeley; S. Hubbard, Lawrence Berkeley Laboratory, Livermore, California.

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Airborne Tracking Sunphotometry

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Sunphotometry is the measurement of the transmission of the solar beam through the atmosphere. Such measurements, made in several narrow bands of ultraviolet, visible, and infrared radiation, provide valuable information on the properties of aerosols and important trace gases such as water vapor and ozone. Atmospheric aerosols (suspensions of particles comprising hazes, smokes, and thin clouds in the troposphere and stratosphere) play important roles in influencing regional and global climates, in determining the chemical composition of the atmosphere, and in modifying transport processes. In all these roles, aerosols interact with trace gases through processes such as evaporation and condensation, photochemical reactions, and mutual interactions with the radiation field. Using a single technique, sunphotometry, to study both aerosols and trace gases is often an advantage in understanding their properties and these interactions.

The objective is to provide unique measurements of aerosols, water vapor, and ozone that address current scientific issues by taking advantage of the three-dimensional mobility of aircraft and other platforms.

Recent advances in understanding climate change, photochemistry, and atmospheric transport and transformation processes have emphasized the need for better knowledge of atmospheric aerosols and their interactions with trace gases. As a result, national and international bodies have called for increased efforts to measure aerosol and trace gas properties and effects, as a means of improving predictions of future climate including greenhouse warming, ozone depletion, and radiation exposure of humans and other organisms.

A fundamental measure of any aerosol or trace gas is how much it attenuates radiation of various wavelengths. This attenuation is often